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FEEDING HABITS OF THE GENET *GENETTA GENETTA* IN AN IBERIAN CONTINENTAL WETLAND

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ABSTRACT - This study quantified the diet of the genet *Genetta genetta* in an Iberian continental wetland, the Galachos Nature Reserve, northern Spain, based on the frequency with which items appeared in five monthly-surveyed latrines during 2004-2005. Prey types were identified *de visu* using identification keys and expert advice. The genet was confirmed as an opportunistic and generalist predator, its diet including mammals (95.0%), plants (68.3%), and arthropods (60.0%) as main prey. With the exception of a newly available prey species, the alien crayfish *Procambarus clarkii*, the genet probably consumed arthropods because of chance encounters rather than active search. The consumption of fruits and small mammals varied seasonally.

Key words: Seasonality, *Apodemus sylvaticus*, *Mus spretus*, protected areas, *Procambarus clarkii*, Spain

RIASSUNTO - ***Alimentazione della genetta* Genetta genetta *in un'area umida continentale della penisola iberica.*** La dieta della genetta è stata investigata in un'area umida interna della Spagna settentrionale, la Riserva Naturale dei Galachos. La frequenza di ciascuna categoria alimentare è stata espressa come numero di occorrenze mensili in cinque latrine monitorate per il periodo 2004-2005. Le categorie sono state identificate *de visu* tramite chiavi per il riconoscimento o l'intervento di singoli esperti. I risultati confermano il comportamento alimentare generalista e opportunista della genetta. La dieta ha incluso principalmente mammiferi (95%), vegetali (68,3%) e artropodi (60%). Questi ultimi, con l'eccezione del gambero *Procambarus clarkii*, introdotto e di recente presenza, sono probabilmente utilizzati in modo opportunistico, piuttosto che in seguito a ricerca attiva. L'uso dei frutti e dei micromammiferi varia stagionalmente.

Parole chiave: Variazioni stagionali, *Apodemus sylvaticus*, *Mus spretus*, aree protette, *Procambarus clarkii*, Spagna

INTRODUCTION

The genet *Genetta genetta* is a medium-sized, carnivorous viverrid which is native to northern Africa. It was introduced into southern Europe several centuries ago and today its populations occupy a wide area on both continents

(Delibes, 1999). The IUCN (2007) consider the species to be of "Least Concern".

The diet is the aspect of genet biology which has been most investigated (Livet and Roeder, 1987; Hamdine *et al.*, 1993; Ruiz-Olmo and López-Martín, 1993; Ballesteros *et al*., 2003), in part because faeces can be easily gathered from latrines. Studies on genet diet have covered a wide geographical range, including northern Africa (Delibes *et al.*, 1989; Hamdine *et al.*, 1993), France (Chanudet *et al*., 1967; Cugnasse and Riols, 1984; Livet and Roeder, 1987; Lodé *et al*., 1991; Le Jaques and Lodé, 1994), Portugal (Rosalino and Santos-Reis, 2002), and Spain (Delibes, 1974; Calviño *et al*., 1984; 1987; Ruiz-Olmo and López-Martín, 1993, 1996; Virgós *et al*., 1999; Arrizabalaga *et al*., 2002; Ballesteros *et al*., 2003; Torre *et al*., 2003). These studies have shown that the genet is a generalist and opportunistic predator (Delibes *et al*., 1989; Calviño *et al*., 1984; Ruiz-Olmo and López-Martín, 1993; Le Jaques and Lodé, 1994; Rosalino and Santos-Reis, 2002). Small mammals, particularly the wood mouse *Apodemus sylvaticus*, are the most important component of the diet (Delibes, 1974; Delibes *et al*., 1989; Palomares and Delibes, 1991; Hamdine *et al*., 1993; Le Jaques and Lodé, 1994; Lodé *et al*., 1991; Ballesteros *et al*., 2003).

Ruíz-Olmo (1993) classified the species as a small-mammal specialist predator, even though its feeding behaviour can vary according to local and seasonal changes in the availability of prey types (Virgós *et al*., 1999).

The diet of the genet in wetlands has been the object of a few studies (Ruiz-Olmo and López-Martín, 1993; Rosalino and Santos-Reis, 2002). In our study, we analysed the diet of the genet in the middle River Ebro Valley, northern Iberia, with the aim of identifying the main prey types and their seasonal variation.

STUDY AREA

The study area covered 751 ha within the Galachos Nature Reserve (GNR), a wetland in the Middle Ebro Valley, near Saragossa, Aragon, Spain (41° 38' 46'', 08 North, 0° 53' 33'', 51 West). The reserve mainly consists of riparian forests (42%) and agricultural lands (27%) (Herrero *et al.*, 2006). In 1994, the GNR was designated as a Special Protection Area under the European Bird Directive because of the high diversity of birds that breed there, particularly night heron *Nycticorax nycticorax*. In 1998, it was designated a Site of Community Importance and included in the Natura 2000 Network. The climate is semi-arid Mediterranean (Rivas and Baselga, 2005), annual rainfall averaging 272 mm.

In the GNR, carnivores include red fox *Vulpes vulpes*, badger *Meles meles*, stone marten *Martes foina*, weasel *Mustela nivalis* and otter *Lutra lutra*. Other medium-sized mammals are European rabbit *Oryctolagus cuniculus* and Iberian hare *Lepus granatensis*.

METHODS

In the first week of each month from July 2004 to June 2005, genet scats were collected from five latrines. The latrine/month was considered as the sample unit. Each month, on average, two fresh scats were removed from each latrine, stored in plastic bags, and kept frozen until analyses. Each sample was thawed and added to water with soap and alcohol to allow its disinte-

gration and avoid the breaking of diagnostic elements. Once the samples were thoroughly soaked, their constituents were separated by pincers in a dry tray.

Hemimandibles and hemimaxilles were used to identify small mammals eaten by the genet (Gállego and Alemany, 1985; Gállego and López, 1985), and were also compared with a reference collection. Birds' feathers were identified by two groups of ornithologists, to allow the comparison of their results. Plant matter was identified using botanical keys (Aizpuru *et al*., 1999) and the floristic catalogue of the GNR (Regato, 1988). Arthropods were identified *de visu* (crayfish) or using available keys (Paulian and Baraud, 1982; Barrientos and Ferrández, 1985; Martínez *et al*., 1985; Chinery, 1997; Baraud, 1992; Vives, 2000). For each item the frequency of occurrence (F%) was calculated as the number of latrines containing the item divided by the total number of latrines/month x 100. Microlepidoptera and dermestid larvae (Coleoptera), also ants (*Tapinoma*, Formicidae, Hymenoptera), were considered contamination of the excrements of the latrine and thus excluded from the analysis.

Seasonal (winter: XII-II, spring: III-V, summer: VI-VIII, autumn: IX-XI) changes in the frequency of use of the main prey types (plant matter, fruits and seeds, crustaceans, arthropods, birds and mammals) were evaluated using the χ^2 test. The p–value for statistical significance was calculated using Holm's sequential Bonferroni method, accepting an overall π value of 0.05 (Rice, 1989). Small mammal consumption, determined through the count of hemimandibles and hemimaxilles, was described on a monthly basis and analysed seasonally.

RESULTS

We collected a total of 135 faecal samples, containing at least 36 different food items (Tab. 1).

The bulk of genet diet consisted of mammals (F% = 95%), particularly wood mouse *Apodemus sylvaticus* (55.0%), Western Mediterranean mouse *Mus spretus* (40%), and greater white-toothed shrew *Crocidura russula* (26.7%). Other mammals included black rat *Rattus rattus* (5.0%) and voles (*Microtus* sp.; 3.3%).

Plant matter, particularly *Poaceae* (26.7%), was common (68.3%), and, in many cases, appeared as an undigested distal branch of faeces. Arthropods, which occurred in 60.0% of the samples, included mainly crayfish (43.3%) and insects (46.7%). The invertebrates most preyed upon included *Coleoptera* (28.3%) - *Dorcus parallelepipedus* (10.0%) and *Amphimalon* sp. (10.0%) -, Orthoptera (21.7%), and large spiders (21.7%). Fruits (58.3%) mostly consisted of figs *Ficus carica* (18.3%), whilst *Passeriformes* (12 species) - especially blackbird *Turdus merula* (6.7%) -, prevailed among birds (46.7%). The frequency of use of fruits and seeds varied significantly among seasons (χ^2 = 13.0, d.f.=3, P < 0.01), showing a peak in autumn (Tab. 2).

The consumption of small mammals varied seasonally (χ^2 = 226, d.f.=3, P < 0.001), rodents being less frequent in genet diet from April through November (Fig. 1).

DISCUSSION

In the GNR, the genet was confirmed as a generalist and opportunistic predator. Its main prey were rodents living in densely vegetated habitats, and crayfish. This preference, together with the frequent presence in the scats of the female flowers of willows and poplar cat-

Table 1 - Diet of the genet (F%) in the Galachos Nature Reserve, northern Spain, based on monthly faecal samples collected from five latrines in 2004-2005 (N = 60 latrines).

FOOD ITEMS	F%	N
PLANT MATTER	68.3	41
Leaves	50.0	30
Compositae	3.3	2
Poaceae	26.7	16
Rosaceae	1.7	1
Salicaceae	1.7	10
Salix sp.	10.0	6
Tamarix gallica	16.7	10
Poligonum sp.	1.7	1
Fruits and seeds	58.3	35
Salicaceae	1.7	1
Populus sp. (cataphylls)	1.7	1
Salix sp.	5.0	3
Moraceae	18.3	11
Ficus carica	18.3	11
Poaceae	5.0	3
Zea mays	1.7	1
Triticum durum	3.3	2
Polygonaceae	16.7	10
Polygonum sp.	10.0	6
Undetermined fruits and seeds	5.0	3
ANIMAL MATTER	98.3	59
Invertebrates	61.7	37
Arthropoda	60.0	36
Aracnida	21.7	13
Procambarus clarkii	43.3	26
Insects	46.7	28
Coleoptera	28.3	17
Cerambycidae	3.3	2
Lamia textor	1.7	1
Ergates faber	1.7	1
Scarabaeidae (Dynastinae)	3.3	2
Phyllognathus excavatus	1.7	1
Oryctes nasicornis	1.7	1
Scarabeidae (Melolonthinae)	11.7	7
Amphimallon sp.	10.0	6
Lucanidae *Dorcus parallelipipedus*	10.0	6
Dermaptera *Forcipula* sp.	3.3	2
Orthoptera	21.7	13
Acrididae	21.7	13

Table 1 - continues

FOOD ITEMS	F%	N
Gryllotalpa gryllotalpa	5.0	3
Undetermined insects	1.7	1
Lepidoptera larvae	13.3	8
Undetermined larvae	1.7	1
Gasteropoda	1.7	1
Vertebrates	96.7	58
Birds	46.7	28
Passeriformes	25.0	15
Aegithalos caudatus	1.7	1
Dendrocopos major	1.7	1
Erithacus rubecula	1.7	1
Luscinia megarhynchos	1.7	1
Passer sp.	1.7	1
Phylloscopus collybita	1.7	1
Sturnus sp.	3.3	2
Sturnus unicolor	3.3	2
Sylvia atricapilla	1.7	1
Turdus merula	6.7	4
Turdus philomelos	1.7	1
Vanellus vanellus	1.2	1
Undetermined birds	21.7	13
Mammals	95.0	57
Crocidura russula	26.7	16
Rodentia	56.7	34
Apodemus sylvaticus	55.0	33
Microtus sp.	3.3	2
Mus spretus	40.0	24
Rattus rattus	5.0	3
Rattus sp.	8.3	5
Undetermined mammals	1.7	1

kins, suggests that riparian forests may be the genet's preferred habitat for seeking food.

Whilst in wetlands of central Portugal (Rosalino and Santos-Reis, 2002) crayfish were very rare in genet diet (<1% of 150 faecal samples), in the GNR crayfish are frequently preyed upon also by wild boar *Sus scrofa* (Herrero *et al*., 2006), confirming the importance of this alien species as prey for multiple secondary consumers in the Iberian Peninsula (see also Pedroso and Santos-Reis, 2007 about the otter).

Among arthropods, insects often are the second most important prey in genet diet (Delibes *et al*., 1989; Hamdine *et al*., 1993; Rosalino and Santos, 2002). In the GNR insects were mostly large, above-ground dwelling, crepuscular species, including many orb web spiders, grasshoppers and beetles, closely

Table 2 - Seasonal variation (F%) of the main items in the diet of the genet in the Galachos Nature Reserve; N. latrines/season: 15; *significant.

Food items	Winter	Spring	Summer	Autumn	χ^2	P
Fruits and seeds	20.0	13.3	33.3	86.7	13	0.005*
Arthropoda	26.7	26.7	66.7	13.3	7.2	0.066
Crustaceans	66.7	40.0	26.7	20.0	5	0.17
Plant matter	46.7	60.0	80.0	53.3	1.5	0.67
Birds	66.7	60.0	53.3	40.0	1.06	0.79
Mammals	100.0	86.7	53.3	93.3	1.06	0.79

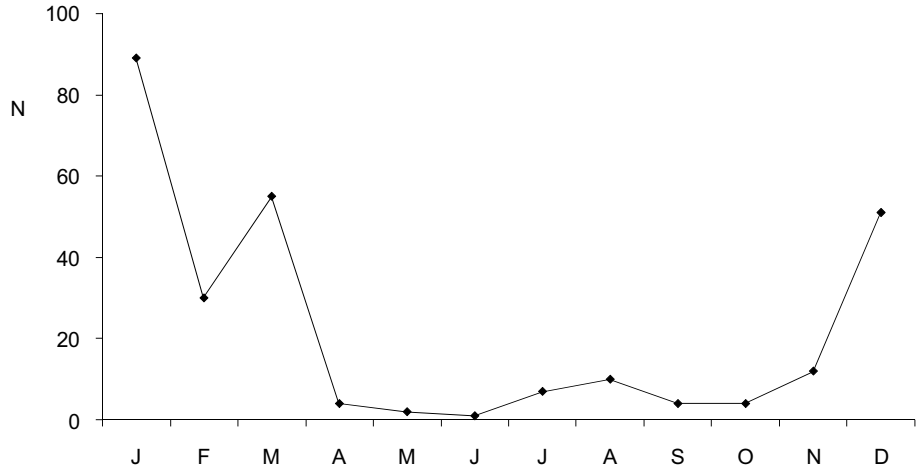

Figure 1 - Number (N) of hemimandibles and hemimaxillas of small mammals found in monthly faecal samples collected from 5 latrines in 2004-2005 (N = 60 latrines).

associated with the vegetation of the area. We suggest that genets consumed them by chance, and not through active searching. The absence of cryptic larvae (living in roots or wood), such as those of some beetles, supports this interpretation.

In some genet populations, birds, mainly thrushes (Turdidae) and other passerines, can represent an important food resource (Le Jacques and Lodé, 1994; Cugnasse and Riols, 1984). In our study area, the genet consumed a wide variety of birds. The presence of a lapwing *Vanellus vanellus* well out of its migratory period suggests that genets rely on defenceless individuals, either young or weakened.

Plant matter was a frequent item in the diet of the genet, but apart from figs, which can represent an important resource (Ballesteros *et al*., 2003), it

mainly consisted of leaves, particularly those of *Poaceae*. These appeared undigested, with unaltered structure and colour, suggesting they were not consumed for their nutritional value. As with other carnivores, genets might eat *Poaceae* to aid digestion, help to eliminate hair from the intestine, induce vomiting to excrete ingested toxins, alleviate throat and stomach inflammations, or as a source of folic acid (Morris, 1996).

Genet diet varies seasonally (Delibes, 1974; Cugnasse and Riols, 1984; Calviño *et al*., 1984; Delibes *et al*., 1989; Palomares and Delibes, 1991; Lodé *et al.,* 1991; Hamdine *et al*., 1993; Ruiz-Olmo and López-Martín, 1993; Le Jaques and Lodé, 1994; Rosalino and Santos-Reis, 2002; Ballesteros *et al.,* 2003), according to the variation of the availability of its various prey or other environmental factors, such as rainfall (Le Jaques and Lodé, 1994). As with previous studies, in the GNR fruit consumption peaked in autumn (Calviño *et al*., 1984; Cugnasse and Riols, 1984; Lodé *et al*., 1991), whilst small mammals were the most common prey in winter (Calviño *et al*., 1984; Rosalino and Santos-Reis, 2002; Ballesteros *et al*., 2003), probably because of their relatively higher availability compared to fruits and Arthropoda in the cold season. The other items did not show any significant variation, particularly birds, which many studies (Calviño *et al.*, 1984; Cugnasse and Riols, 1984; Lodé *et al.*, 1991; Le Jaques and Lodé, 1994) have reported to be more frequent in winter and spring, coinciding with the breeding seasons of many species at our latitudes.

The pattern of seasonal variation found in the GNR with respect to other studies could be due either to environmental factors, such as climate and prey availability, or to sample size.

In general, our results are similar to those of previous studies based on the analysis of gastric contents or faeces (Braña and Del Campo, 1982; Delibes *et al.* 1989; Hamdine *et al.,* 1993; Rosalino and Santos, 2002; Le Jacques and Lodé, 1994), even though they sometimes sharply differ in their methods and sample size (36 in Braña and Del Campo, 1982; 150 in Torre *et al.,* 2003; more than 2000 in Lodé *et al.,* 1991), making comparisons rather difficult. For instance, the extraction of diagnostic elements from faeces can be achieved using re-hydrated, oven-dried excrements (Palomares and Delibes, 1991; Lodé *et al.* 1991), faecal samples hydrated with different dilutions (Delibes *et al.,* 1989; Ruíz-Olmo and López Martín, 1993, 1996; Arrizabalaga *et al.,* 2002; Roberts *et al.* 2007) or with no previous treatment (Calviño *et al.,* 1984; Ballesteros *et al.,* 2003). In some cases, the method used is either partially (Hamdine *et al.,* 1993) or not at all explained (Rosalino and Santos-Reis, 2002; Torre *et al.,* 2003). Finally, the deterioration of the diagnostic elements is a main problem of faecal analyses. Further research on genet feeding behaviour in wetlands is needed to better understand the species on which the genet preys.

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